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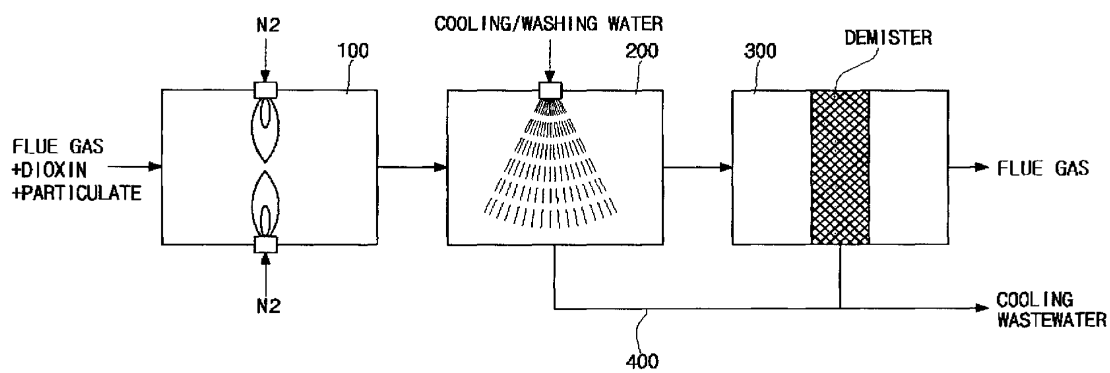
(54) **Title:** METHOD AND APPARATUS FOR EXCLUDING DIOXIN AND FLY ASH USING HIGH TEMPERATURE PLASMA



(57) **Abstract:** Disclosed relates to a dioxin removal apparatus, and specifically it relates to a dioxin and particulate removal apparatus and method using a thermal plasma, in which flue gas generated from wastes incineration facilities is completely combusted, and then the flue gas is rapidly cooled by spraying waters to the flue gas to prevent the denovo-synthesis of dioxin r generation of nitrates in the subsequent process and simultaneously various environmental pollutants in the flue gas are washed out. The method of the present invention comprise the steps of a decomposition step of thermo-chemically destroying the flue gas containing dioxin, soot, particulate, and incomplete combustion products, generated from the incineration facility, by using a thermal plasma; a cooling and washing step of rapid cooling the hot flue gas in the decomposition step and simultaneous washing pollutants in the flue gas; a dewatering step of reducing water content in the flue gas cooled in the cooling and washing step; and a wastewater discharging step of discharging cooling water used in the cooling and washing step (200) and in the dewatering step (300).

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METHOD AND APPARATUS FOR EXCLUDING DIOXIN AND FLY ASH USING HIGH TEMPERATURE PLASMA

Technical Field

The present invention relates to a dioxin removal apparatus, and more particularly, to a dioxin and particulate removal apparatus and method using thermal plasma, in which the flue gas emitted from waste incinerators is completely combusted, and then the flue gas is rapidly cooled by spraying cooling and cleaning waters to the flue gas so as to prevent the re-synthesis (de novo synthesis) of dioxin or generation of nitrogen oxides in the subsequent process, and simultaneously various environmental pollutants contained in the flue gas are washed.

Background Art

With a rapid industrialization and urbanization, industrial and municipal solid wastes are increasing continuously. Therefore, Many technologies are being developed to treat various wastes more environmental friendlily. Among them, incineration is recognized to be a favorable wastes treatment technology that it can greatly reduce the amount of wastes and recover energy. However, the flue gas generated at the time of the waste incineration

includes many kinds of environmental contaminants such as dioxin, nitrogen oxides, sulfur oxides, particulate, etc. Especially, the generation of dioxin as a carcinogen and an endocrine disrupter becomes an obstacle to installation and operation of incinerator.

In general, dioxin refers to organic compound such as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenxofurans (PCDFs). The dioxin is not decomposed well in the natural state because its molecular structure is very stable. Once it is introduced into the human body, it is easily not excreted but accumulated in the human body, which contributes to the cause of cancer, the disorder of hormone regulation functions, or the damage to the reproductive and immune systems. Thus it is a very noxious substance.

Dioxin is generated through various paths. It is included mainly in wastes at the facilities for incinerating municipal solid wastes. Also, chlorinated precursors such as chlorinated phenol, chlorinated benzene, polyvinyl chloride(PVC), etc., which is generated in an incomplete combustion process, produce a dioxin through a certain reaction in a incinerator, or, chlorinates included with organic substances and chlorine make into a dioxin properly through a substitution reactions. But dioxin is destroyed in the incinerator when the combustion temperature is above a 900

°C. For example, the amount of dioxin observed at the outlet of the high temperature incinerator is low relatively.

On the other hand, it is found that hydrocarbons produced by incomplete combustion in the incinerator react at a temperature of 250 to 350 °C with chlorine donor on the surface of fly ash contained in the combustion gas. In the process of reaction between hydrocarbon and chlorine, the amount of dioxin is produced a relatively high concentration. In other words, it should not be detected at a chimney of incineration facilities because the dioxin in the incinerator is destroyed in the combustion process. But it can be seen that dioxin is synthesized in actual after leaving the incinerator from the fact of a significant amount of dioxin. This has been already confirmed that an amount of dioxin is generated in combustion gas emitted through an economizer or electrostatic precipitator at 250 to 350 °C.

As such, the reason why dioxin is generated vigorously at 250 to 350 °C is that chlorine is generated vigorously from chloride by catalysis of copper, etc., in this temperature range. Therefore, the reduction of dioxin is accomplished as the followings; firstly, the incinerator should be operated at the condition of complete combustion to minimize the production of various precursors by means of maximizing the destruction of organic materials. Secondly, the temperature range which dioxin can be generated in post-

processes should be avoided, or the retention time should be minimized when the incinerator is operated in the temperature range.

The dioxin removal apparatuses in use in wastes incineration facilities is largely included a combination of spray dryer absorption (SDA), selective catalyst reactor (SCR), selective non-catalytic reduction (SNCR), a dust collector system, and an absorption method using activated carbon. Especially, a new method added a dust collector system to SDA to remove acidic gas in flue gas and heavy metals is known to be excellent for removal of dioxin. It is known that the dust collection system combined with SNCR as a technology of injecting ammonia into an incinerator for removing NOx in the incinerator is effective. Such a method is effective in inhibiting the generation of dioxin. Also, the dust collection system combined with SCR can achieve above 90% of dioxin removal when the incinerator is operated in an optimum temperature range. However, the above-mentioned process requires the additional dust collection system and collected contaminants should be treated as an industrial wastes. In case of using a catalyst, catalytic activity can be sharply reduced by heavy metals. Thus the conventional methods have a problem in that they need a high cost for installation and operation. For example, a post-treatment facility for removal of heavy metals and extremely fine dusts needs to be installed.

And, a method of absorbing dioxin using a mixture of activated carbon, coke and limestone are divided into two types. One is a method of adsorbing dioxin, etc. by allowing flue gas to pass through the fixed-bed adsorption column. The other is a method of adsorbing dioxin by allowing flue gas to pass through a bag filter, in which limestone and powered activated carbon are sprayed into flue gas for the adsorbing dioxin, and followed by the removal of dioxin in the bag filter. However, the adsorption methods using activated carbon has many problems as followings; overload occurring in the dust collection system due to the added activated carbon, the reduction of life time of the filter bag, difficulty in performance improvement, and shortage of required space for facility expansion.

Accordingly, there are the needs for developing new technologies that can solve these problems. In consideration of dioxin formation mechanisms and practical operation conditions in the incinerator, a presenter has accomplished the present invention that can completely combust flue gas emitted from incinerator by using of thermal plasma, and then rapidly cool and simultaneously wash the flue gas. So that dioxin precursors contained in the flue gas are prevented from being re-synthesized, and acidic materials such as nitrate are prevented from being generated. As a result, various contaminants included in flue gas are removed completely.

Disclosure of Invention

Therefore, the present invention has been made in view of the problems of the prior technologies described above. The main object of the present invention is to provide a dioxin and particulate removal apparatus and method which can completely combust dioxin precursors, fly ash, soot, and other incomplete combustion products contained in flue gas, which is discharged from various industrial facilities and incinerators using thermal plasma. And then rapidly cool the flue gas so as to prevent the re-synthesis(de novo synthesis) of dioxin precursors and the generation of nitrogen oxides and simultaneously wash the flue gas, thereby removing various environmental contaminants such as hydrogen chloride, sulfur oxides, particulate, etc. contained in the flue gas.

To achieve the above mentioned object, according to an aspect of the present invention, there is provided a dioxin and particulate removal method using thermal plasma, the method comprising the steps of: a decomposition step of thermo-chemically destroying dioxin, soot, particulate, and incomplete combustion products in the flue gas generated from the incineration facility, by using a thermal plasma; a cooling and washing step of rapidly cooling the hot flue gas generated in the decomposition step and

simultaneously washing pollutants in the flue gas; a dewatering step of reducing water content in the flue gas cooled in the cooling and washing step; and a wastewater discharging step of discharging cooling water used in the cooling and washing step and wastewater condensed in the dewatering step.

Preferably, the decomposition step keeps the temperature of the flue gas above 900 °C using thermal plasma, and the flue gas temperature is lowered by the cooling and washing step rapidly below 200 °C.

According to another aspect of the present invention, there is also provided a dioxin and particulate removal apparatus using thermal plasma, comprising: a reaction chamber for introducing flue gas containing dioxin precursors, soot, fly ash, and incomplete combustion products generated from incineration facility thereto; thermal plasma torch installed at one side of the reaction chamber for completely combusting the flue gas introduced into the reaction chamber using thermal plasma; a cooling and washing chamber installed adjacent to the reaction chamber and having cooling water spraying nozzles mounted on the ceiling portion thereof, for rapid cooling the flue gas discharged from the reaction chamber so as to prevent the denovo-synthesis of dioxin and the generation of nitrogen oxides and simultaneous washing hydrogen sulfide, sulfur oxides, particulate, etc., in the flue gas; a

demister installed adjacent to the cooling and washing chamber for reducing water content in the flue gas generated in the cooling and washing chamber; and a waste water discharging method for discharging wastewater generated in the cooling and washing chamber and the demister.

Preferably, the thermal plasma torch makes a thermal plasma flame of above 900 °C by ionizing the nitrogen gas (N2) using direct current arc electric discharge or high frequency inductive coupling electric discharge.

Preferably, the thermal plasma torch includes a torch body formed of a cylindrical hollow tube; a cathode rod installed inside of the torch body; a nitrogen gas inlet installed at one side of the torch body for injecting a nitrogen gas into the torch body therethrough; cooling water inlet installed at one side of the torch body for injecting cooling water into the torch body therethrough so as to circulate the injected cooling water within the hollow tube of the torch body; and a power supply methods for applying power to the torch body and the cathode rod.

According to another aspect of the present invention, there is also provided a dioxin and particulate removal apparatus using thermal plasma, comprising: a reaction chamber installed on a duct in-line of the wastes incineration facility for introducing flue gas containing dioxin, dioxin precursors, soot, fly ash, incomplete combustion products, etc., generated

from the incineration facility thereto, the reaction chamber having thermal plasma torches installed therein for completely combusting the flue gas introduced thereto; a cooling and washing chamber installed adjacent to the reaction chamber and having cooling water spraying nozzles mounted on the ceiling portion thereof, for rapid cooling the flue gas discharged from the reaction chamber and simultaneous washing pollutants in the flue gas; a demister adjacent to the cooling and washing chamber for reducing water content in the flue gas generated in the cooling and washing chamber; and a wastewater discharging means for discharging wastewater generated in the cooling and washing chamber and the demister.

Preferably, the temperature of the reaction chamber is maintained above 900 °C, more preferably, above 1500 °C.

Also preferably, the plasma torches are installed in the reaction chamber in such a manner as to be arranged in zigzags therein to homogenize the temperature inside of the reaction chamber or slantingly arranged to agitate the flue gas injected into the reaction chamber.

Preferably, the reaction chamber is made of a heat resistant material that can endure high temperature and having a cooling unit installed at the outside thereof for protecting the inside wall thereof.

Further preferably, the cooling and washing chamber has cooling

water spraying nozzles installed on the ceiling portion, reduces the temperature of the flue gas to below 200 °C rapidly by spraying fine water droplet.

Brief Description of Drawings

Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic flow diagram showing the dioxin and particulate removal method using thermal plasma according to the present invention;

FIG. 2 is a cross section showing an example of the thermal plasma torches according to the present invention;

FIG. 3 is a schematic partial cross sectional view showing the dioxin and particulate removal apparatus using thermal plasma according to an preferred embodiment of the present invention;

FIG. 4 is a cross sectional view showing the dioxin and particulate removal apparatus using thermal plasma according to another preferred embodiment of the present invention;

FIG. 5 is a cross sectional view showing the dioxin and particulate removal apparatus using thermal plasma according to still another preferred

embodiment of the present invention;

FIG. 6 and FIG. 7 are schematic cross sectional views showing the dioxin and particulate removal apparatus using thermal plasma according to further another preferred embodiments of the present invention.

Best Mode for Carrying Out The Invention

FIG. 1 is a schematic diagram showing the dioxin and particulate removal method using thermal plasma according to the present invention. As shown in FIG. 1, the dioxin and particulate removal method of the present invention includes a decomposition step 100 of destroying thermo-chemically the flue gas containing dioxin, particulate, and incomplete combustion products using thermal plasma; a cooling and washing step 200 of rapidly cooling the flue gas of a high temperature generated in the decomposition step 100 and of simultaneously washing contaminants contained in the flue gas; a water removal step 300 of removing water contained in the flue gas cooled in the cooling and washing step 200; and a cooling wastewater discharge step 400 of discharging cooling water used in the cooling and washing step 200 and wastewater generated in the water removal step 300.

The decomposition step 100 according the present invention is

performed in an incinerator of wastes incineration facilities. In the decomposition step, the flue gas containing dioxin, dioxin precursors, fly ash, incomplete combustion products, etc. is introduced into the reaction chamber of a proper size, and at the same time, dioxin and dioxin precursors, fly ash, and incomplete combustion products are completely combusted to be decomposed, using thermal plasma emitted from one or more thermal plasma torches installed in the reaction chamber. In other words, dioxin starts to be decomposed at above 800 °C and is completely decomposed at 1200 °C. Fly ash is re-combusted at a high temperature. Thus, not only is dioxin precursors adsorbed in fly ash decomposed, but also its absorption ability is lost since its structure is destructed. Therefore, the thermal plasma is maintained preferably above 900 °C, and more preferably above 1500 °C.

As such, the first step of the dioxin and particulate removal method according to the present invention is a process of making flue gas with non-toxic materials, by eliminating dioxin and dioxin precursors generated unavoidably due to incomplete combustion and fly ash involved in dioxin re-synthesis(de novo synthesis) at post-treatment processes, through re-combusting flue gas with high temperature.

The flue gas discharged in the decomposition step 100 progresses to the cooling and washing step 200. That is, the flue gas discharged in the

decomposition step 100 is at a high temperature of above 1000 °C, and when this high temperature state is maintained for more than a certain time, nitric oxide (NO) reacts with oxygen to produce nitrogen oxides(NOx). Thus the flue gas should be cooled to below the reaction temperature. Also, when even dioxin or dioxin precursors decomposed in the decomposition step 100 stay in a proper temperature range of, for example, 250 to 300 °C, for above a certain time period, they are synthesized again to produce dioxin. Therefore, it is required to reduce the temperature of the flue gas below 200 °C. Also, when the flue gas is cooled from high temperature to below 200 °C in the decomposition step 100, it passes through the temperature range where NOx and dioxin are generated. Hence, it is important to rapidly cool the flue gas in order to shorten the retention time in the reaction temperature.

As such, the second step of the dioxin and particulate removal method according to the present invention includes a step of rapidly cooling flue gas of a high temperature to below 200 °C, more preferably below 70 °C. The cooling and washing step 200 is a process of cooling the flue gas through a manifold of cooling water injection nozzles installed in the cooling and washing chamber(wet scrubbing chamber) of a prescribed size. Thus the cooling process is rapidly performed by using the latent heat of cooling water, and also there are an effect of washing particulate and acidic

contaminants such as SOx, HCl, etc., contained in the flue gas.

And, cooling water is sprayed directly to the flue gas of a high temperature to rapidly cool the flue gas in the cooling and washing step 200. Hence a large amount of water is generated. Therefore, the cooling and washing step 200 is followed by the wastewater removal step. Cooling wastewater generated in the cooling and washing step 200 and the water removal step 300 is drained to the outside through a separate discharge step 400, and preferably is transported to a wastewater treatment unit which in turn purifies the cooling wastewater for discharge to the water body or reuse it as cooling water.

As described above, the dioxin and particulate removal processes using thermal plasma of the present invention are simpler than a conventional activated carbon adsorption method or a combination of SDA, or SNCR and a dust collector. In addition, management is easy since a separate post-treatment except the cooling wastewater treatment is not required.

Also, since the prior flue gas removal apparatus using low temperature plasma is big in size and complicated, it requires a separate post-treatment process necessarily, but the present invention is small in size and relatively simple in structure.

Subsequently, FIG. 2 is a cross sectional view showing an example of the thermal plasma torches used in the dioxin and particulate removal apparatus using thermal plasma according to the present invention. These thermal plasma torches 20 use a direct current arc electric discharge or high frequency inductive coupling electric discharge to allow a strong electric field to be generated in inert gases such as Ar and He or used gases such as N2, H2, air or O2, water vapor, hydrocarbon gas, etc., so as to produce a thermal plasma by generating electric charges through continuous collisions of accelerated electrons. The thermal plasma (or heat plasma) is in local equilibrium, where ionized particles are maintained at the same temperature. Thus, the plasma is much higher in temperature than low temperature plasma (or cold plasma) having low heat content, where heavy ions and neutral particles are in non-equilibrium at a temperature near room temperature.

As shown in FIG. 2, the thermal plasma torch 20 consists of a torch body 23 formed of cylindrical hollow tubes; a cathode rod 25 installed inside the torch body 23; and a power supply means for applying a prescribed voltage between the cathode rod 25 and the torch body 23. Hence, if gases such as N2, etc. are injected into the torch body installed with the cathode rod 25, arc electric discharge occurs at an end of the cathode rod 25 to emit a thermal plasma flame 27. Meanwhile, a cooling water inlet 28 and outlet 29

are installed in a hollow tube of the torch body 23 to allow circulation of cooling water within the torch body so as to protect the torch body 23 from high temperature heat.

And, FIG. 3 is a schematic cross sectional view showing the thermal plasma torch 20 installed at a discharge outlet of an incineration facility. As shown in FIG. 3, a reaction chamber 24 is formed at the lower portion of the torch body 23 to re-combust the flue gas generated in the incineration furnace by the thermal plasma flame 27. Hence, the contaminants contained in the flue gas introduced into the reaction chamber 24 are decomposed by thermal plasma to be discharged to the outside through a discharge outlet 37.

Meanwhile, FIG. 4 and FIG. 5 are schematic cross sectional views showing the dioxin and particulate removal apparatus using thermal plasma according to a preferred embodiment of the present invention. As shown in FIG. 4 and FIG. 5, the dioxin and particulate removal apparatus 10 using thermal plasma according to the present invention includes the thermal plasma torch 20 for generating the thermal plasma; a cooling and washing room 30 having cooling water injection nozzles 33 installed therein, for rapidly cooling flue gas at high temperature discharged after the flue gas is thermo-chemically decomposed in the reaction chamber 24 installed at the bottom portion of the thermal plasma torch and simultaneously washing

contaminants; a demister 40 for removing water generated in the cooling and washing room 30; and a storage tank 50 for temporarily storing cooling wastewater generated in the cooling and washing room 30 and the demister 40.

In other words, as shown in FIG. 4, if a direct current or high frequency electric power source is connected between the plasma torch body 23 and the cathode rod 25 and nitrogen is injected into a reaction chamber through a nitrogen gas inlet (29), then the nitrogen molecules is decomposed into electrons and positive ions to make a thermal plasma. And, if the flue gas containing contaminants such as dioxin and dioxin precursors is injected into the reaction chamber 24 formed at the bottom of the torch body 23 through flue gas inlet 26, the thermal plasma flame 27, described above, decomposes organic compounds. The high temperature flue gas discharged from the reaction chamber 24 is cooled by cooling water sprayed from a cooling water injection nozzle (33) installed near the plasma torch 20. Therefore, the flue gas discharged at the plasma torch 20 is rapidly cooled to below 200 °C, more preferably below 100 °C. Hence, the present invention prevents the re-synthesis(de novo synthesis) of dioxin and the generation of nitrogen oxides that may be formed by the retention of flue gas at a particular high temperature range for more than a certain time period.

Meanwhile, FIG. 5 is a cross sectional view showing the dioxin and particulate removal apparatus using thermal plasma according to the present invention, in which the reaction chamber 24 for decomposing the flue gas containing contaminants by plasma gas therein and the cooling and washing room 30 for cooling the high temperature flue gas with cooling water therein are divided by a separate partition. That is, the flue gas decomposed thermo-chemically in the reaction chamber 24 is rapidly introduced into the cooling and washing room to be cooled with cooling water. Here, since the flue gas is transferred forcedly by a blower (not shown), the water generated in the cooling and washing room is not introduced into the reaction chamber.

Subsequently, FIG. 6 and FIG. 7 are cross sectional view showing the dioxin and particulate removal apparatus using thermal plasma according to another embodiments of the present invention. As shown in FIG. 6 and FIG.7, a reaction chamber 60 for decomposing contaminants using thermal plasma and a cooling and washing room 30 for cooling and washing flue gas using cooling water are installed on a duct in-line of a wastes incineration facility.

In other words, the reaction chamber 60 is installed for introducing the flue gas generated from the incineration furnace thereto and has at least one more thermal plasma torch 20 installed therein. Thus, the reaction chamber 60 is maintained above at least 900 °C, more preferably above 1500

°C. Especially, since the reaction chamber of the present embodiment is disposed outside the thermal plasma torch 20, a manifold of plasma torches 20 are properly arranged so that the flue gas passing through the reaction chamber 60 can contact the thermal plasma flames sufficiently. For example, in FIG. 6, a manifold of plasma torches 20 are arranged in zigzags to homogenize the temperature inside the reaction chamber 60, and in FIG. 7, a manifold of plasma torches 20 are askew arranged to agitate the flue gas to cause cyclone phenomena, thereby promoting thermal decomposition reaction.

Meanwhile, the reaction chamber 60 is made of a heat resistant material that can endure high temperature of above 1500 °C, and a separate cooling unit 63 is installed outside the reaction chamber 60 for protecting the inside wall of the reaction chamber 60. And, the size and shape of the reaction chamber 60 may be properly selected by a engineer skilled in the field, depending on the discharge amount of flue gas to be discharged from an incineration facility.

Subsequently, a cooling and washing room 90 is installed adjacent to the reaction chamber 60 so that the flue gas of a high temperature from the reaction chamber 60 is rapidly transferred to the cooling and washing room 90 which in turn cools the flue gas. In this case, the flue gas is transferred to

the cooling and washing room 90 by a blower and an inlet fan(not shown). The cooling and washing room (90) is intended for the flue gas of a high temperature to be cooled by the latent heat absorbed when liquid evaporates to gas, and has a manifold of cooling water injection nozzles installed on the ceiling portion of thereof, for spraying cooling water as fine water drops. Therefore, while the flue gas of a temperature of above 900 °C discharged from the reaction chamber 60 passes through the cooling and washing room 90, it is rapidly cooled to below 200 °C, more preferably below 100 °C.

Meanwhile, while contaminants such as sulfur oxides, particulate, etc., contained in the flue gas, pass through the cooling and washing room 90, they are cooled by cooling water sprayed from the cooling water injection nozzles 33. In other words, since inorganic contaminants such as sulfur oxides are not decomposed in the reaction chamber 60, they are washed in the cooling and washing room 90 to be removed, thus removing all the contaminants contained in the flue gas.

And, the flue gas discharged from the cooling and washing room (90) contains a large amount of water. Thus a demister (40) is installed at the rear end portion of the cooling and washing room (90), for removing water. Cooling wastewater generated from the cooling and washing room (90) and the demister (40) is discharged to the outside through a cooling wastewater

collecting part (53) and a discharge tube (55) installed below the cooling and washing room (90) and the demister (40).

Now, the experimental examples of the dioxin and particulate removal apparatus using thermal plasma according to the present invention will be described hereinafter.

Experimental Example 1

Experimental Example 1

<Consist of the experimental apparatuses>

The removal apparatus for dioxin and particulate using a thermal plasma, which was invented here was shown in FIG. 5. Plasma gas produced while passing through the plasma emission region at a flow rate of 18 L/min and flue gas containing dioxin were mixed with each other. Nitrogen ($N2$) was used [for what?] and water was used for cooling electrodes of the plasma emission region. The water was sprayed to the hot flue gas passed through the plasma emission region through cooling water nozzles in order to prevent nitrogen oxides production or dioxin denovo-synthesis.

Experimental Example 2

<Experimental method>

In order to determine the dioxin removal efficiency of the thermal plasma reactor, flue gas containing dioxin was taken from an incineration facility at a flow rate of 200 L/min and the flue gas was introduced into the thermal plasma reaction chamber. The dioxin concentration of flue gas was measured twice when plasma was on-state and off-state respectively at the rear end of the reaction chamber. And the dioxin concentration was determined according to procedure of Article no. 29 of Korean Standard Method for Air Pollution. When plasma was on, the power consumption was 7.1 kW.

Experimental Example 3

<Experimental result>

The measurement results of dioxin concentration were shown in the following table. The removal efficiency was 97.2%

<Table>

Classification			Plasma off (Inlet Concen.)	Plasma on (Outlet Concen.)	Efficiency (%)
Dioxin (PCDDs/DFs)	1st	Solid	4.54	0.09	
		Liquid	1.24	0.02	

		Total	5.78	0.11	
	2nd	Solid	2.36	0.11	
		Liquid	0.10	0.01	
		Total	2.46	0.12	
Average			4.12	0.115	97.2

Since the temperature of the high temperature emission region is higher than 10,000 K and dioxins are decomposed at higher than 900 °C, can be completely destroyed in this thermal plasma treatment unit. At the same time, particulate residues which had not been combusted in the flue gas would be completely combusted at high temperature. Therefore byproducts generation also is small.

As described above, the dioxin and particulate removal apparatus using thermal plasma can remove above 92% of dioxin, particulate, and other various environmental pollutants. Hence, the dioxin and particulate removal apparatus may be applied to the treatment of flue gas discharged from not only incineration facilities for domestic solid wastes but also various industrial facilities such as industrial wastes incineration facilities, thermo-decomposition facilities for waste plastics, steel factories, oil purification facilities, etc.

Industrial Applicability

As described above, the dioxin and particulate removal method and apparatus using thermal plasma can completely combusts various pollutants such as dioxin in flue gas discharged from wastes incinerators using a thermal plasma, and simultaneously it can rapidly cool and wash the flue gas so as to prevent denovo-synthesis of dioxin and the generation of nitrogen oxides. And also it removes various pollutants such as sulfur oxides, particulate, etc. in the flue gas.

Also, compared to other technologies, in this invention, neither activated carbon nor lime is used. Also, particulates in the flue gas are completely combusted using thermal plasma so that little amount of byproducts are produced in this invention. Therefore, a separate apparatus for post-treatment processes such as collectors may be omitted. Hence, the installation cost is reduced and the operation and management is easier.

Claims

1. A dioxin and particulate removal method using thermal plasma, the method comprising the steps of:

a decomposition step (100) of thermo-chemically destroying dioxin, soot, particulate, and incomplete combustion products in the flue gas generated from the incineration facility, by using a thermal plasma;

a cooling and washing step (200) of rapidly cooling the hot flue gas generated in the decomposition step (100) and simultaneously washing pollutants in the flue gas;

a dewatering step (300) of reducing water content in the flue gas cooled in the cooling and washing step (200); and

a wastewater discharging step (400) of discharging cooling water used in the cooling and washing step (200) and wastewater condensed in the dewatering step (300).

2. The dioxin and particulate removal method using thermal plasma as recited in claim 1,

wherein the decomposition step keeps the temperature of the flue gas above 900 °C using a thermal plasma.

3. The dioxin and particulate removal method using thermal plasma as recited in claim 1,

wherein the cooling and washing step rapidly lowers the flue gas temperature below 200 °C by spraying cooling water.

4. A dioxin and particulate removal apparatus using thermal plasma, comprising:

a reaction chamber for introducing flue gas containing dioxin precursors, soot, fly ash, and incomplete combustion products generated from incineration facility thereto;

thermal plasma torch installed at one side of the reaction chamber for completely combusting the flue gas introduced into the reaction chamber using thermal plasma;

a cooling and washing chamber installed adjacent to the reaction chamber and having cooling water spraying nozzles mounted on the ceiling portion thereof, for rapid cooling the flue gas discharged from the reaction chamber so as to prevent the denovo-synthesis of dioxin and the generation of nitrogen oxides and simultaneous washing hydrogen sulfide, sulfur oxides, particulate, etc., in the flue gas;

a demister installed adjacent to the cooling and washing chamber for

reducing water content in the flue gas generated in the cooling and washing chamber; and

a waste water discharging method for discharging wastewater generated in the cooling and washing chamber and the demister.

5. The dioxin and particulate removal apparatus using thermal plasma as recited in claim 4,

wherein the thermal plasma torch makes thermal plasma flame of above 900 °C by ionizing the nitrogen gas (N2) using direct current arc electric discharge or high frequency inductive coupling electric discharge.

6. The dioxin and particulate removal apparatus using thermal plasma as recited in claim 4,

wherein the thermal plasma torch includes a torch body formed of a cylindrical hollow tube; a cathode rod installed inside of the torch body; a nitrogen gas inlet installed at one side of the torch body for injecting a nitrogen gas into the torch body therethrough; cooling water inlet installed at one side of the torch body for injecting cooling water into the torch body therethrough so as to circulate the injected cooling water within the hollow tube of the torch body; and a power supply methods for applying power to

the torch body and the cathode rod.

7. A dioxin and particulate removal apparatus using thermal plasma, comprising:

a reaction chamber installed on a duct in-line of the wastes incineration facility for introducing flue gas containing dioxin, dioxin precursors, soot, fly ash, incomplete combustion products, etc., generated from the incineration facility thereto, the reaction chamber having thermal plasma torches installed therein for completely combusting the flue gas introduced thereto;

a cooling and washing chamber installed adjacent to the reaction chamber and having cooling water spraying nozzles mounted on the ceiling portion thereof, for rapid cooling the flue gas discharged from the reaction chamber and simultaneous washing pollutants in the flue gas;

a demister adjacent to the cooling and washing chamber for reducing water content in the flue gas generated in the cooling and washing chamber; and

a wastewater discharging means for discharging wastewater generated in the cooling and washing chamber and the demister.

8. The dioxin and particulate removal apparatus using thermal plasma as recited in claim 7,

wherein the temperature of the reaction chamber is maintained above 900 °C.

9. The dioxin and particulate removal apparatus using thermal plasma as recited in claim 7,

wherein the plasma torches are installed in the reaction chamber in such a manner as to be arranged in zigzags therein to homogenize the temperature inside of the reaction chamber or slantingly arranged to agitate the flue gas injected into the reaction chamber.

10. The dioxin and particulate removal apparatus using thermal plasma as recited in claim 7,

wherein the reaction chamber is made of a heat resistant material that can endure high temperature and having a cooling unit installed at the outside thereof for protecting the inside wall thereof.

11. The dioxin and particulate removal apparatus using thermal plasma as recited in claim 7,

wherein the cooling and washing chamber has cooling water spraying nozzles installed on the ceiling portion, reduces the temperature of the flue gas to below 200 °C rapidly by spraying fine water droplet.

Fig. 1

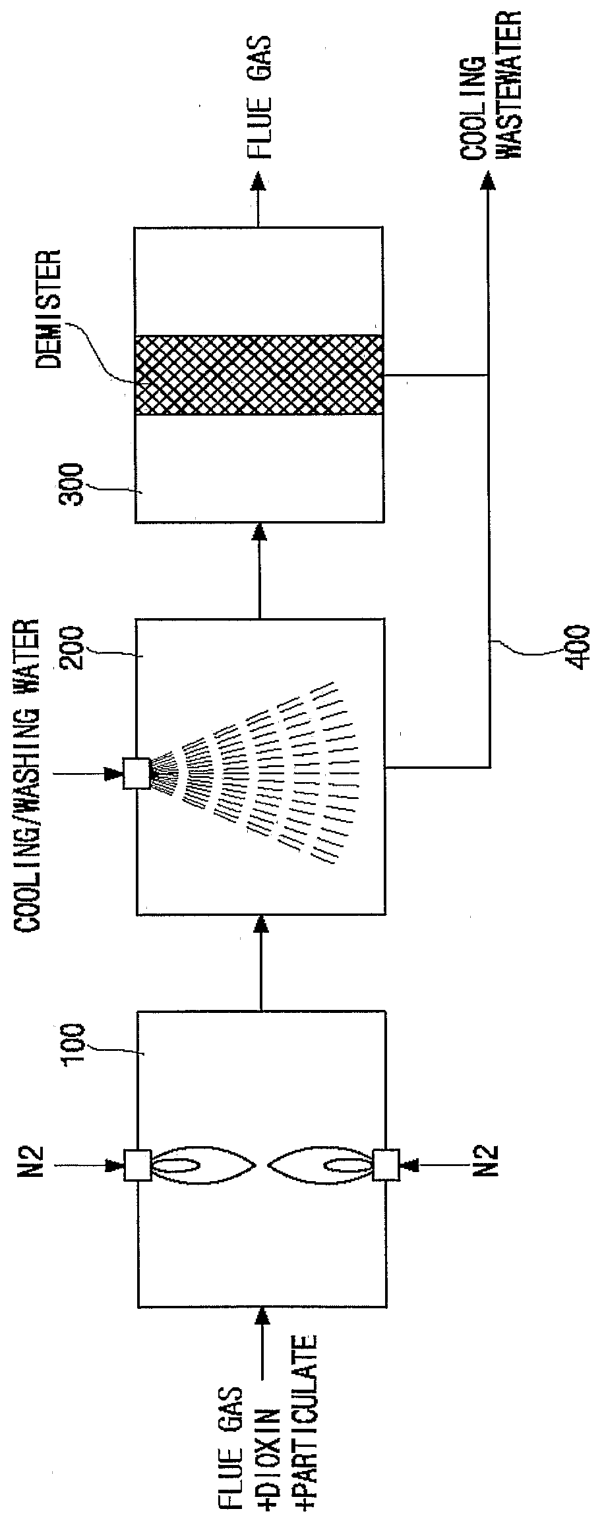

FLUE GAS
COOLING
WASTEWATER
DEMISTER
300
COOLING/WASHING WATER
200
400
100
N2
N2
FLUE GAS
+DIOXIN
+PARTICULATE

Fig. 2

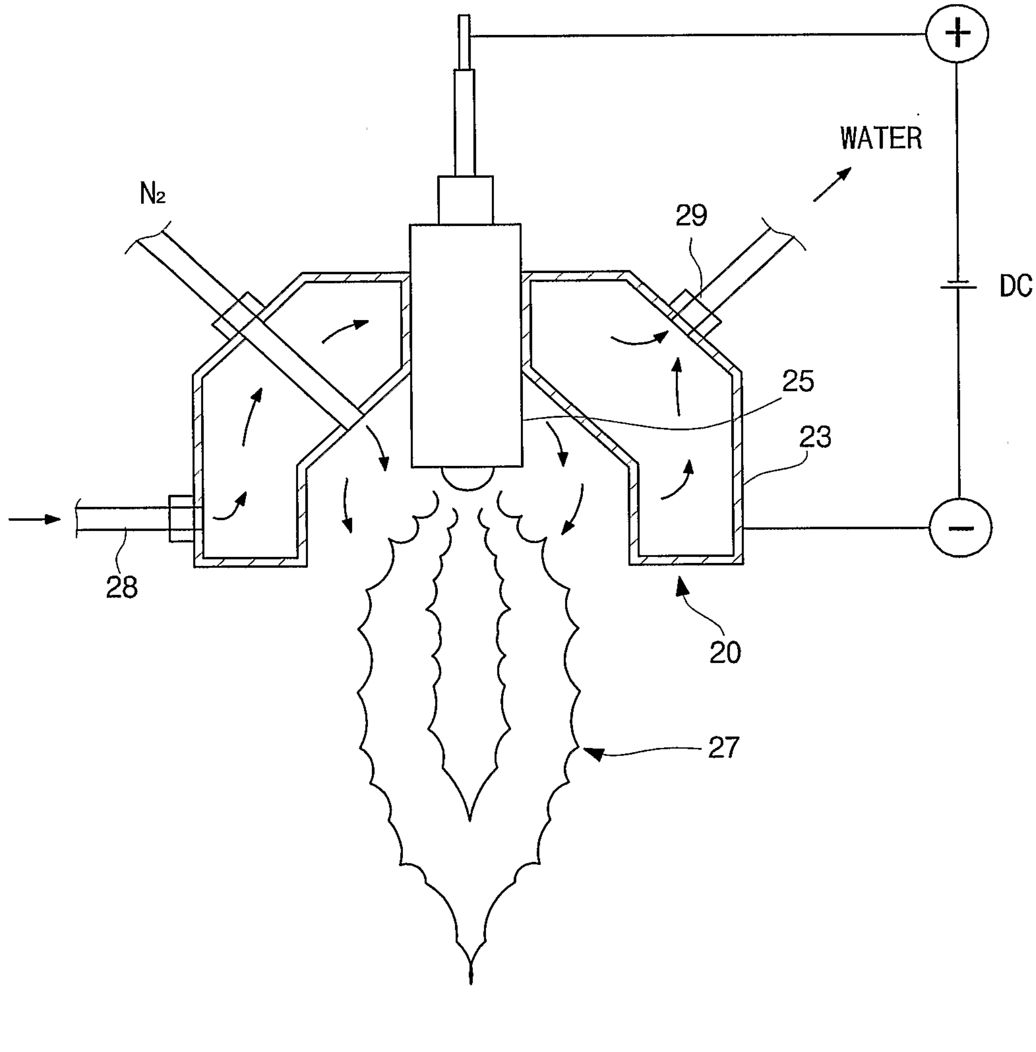


Fig. 3

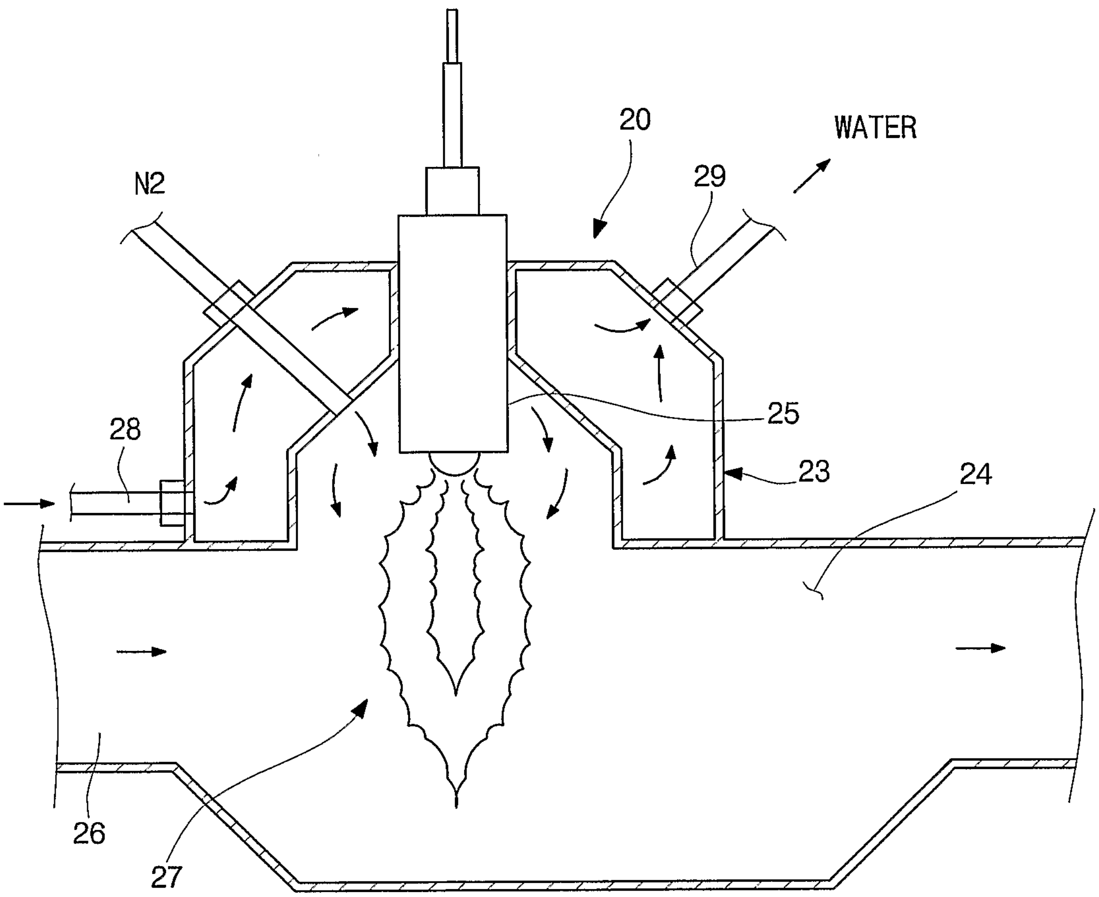


Fig. 4

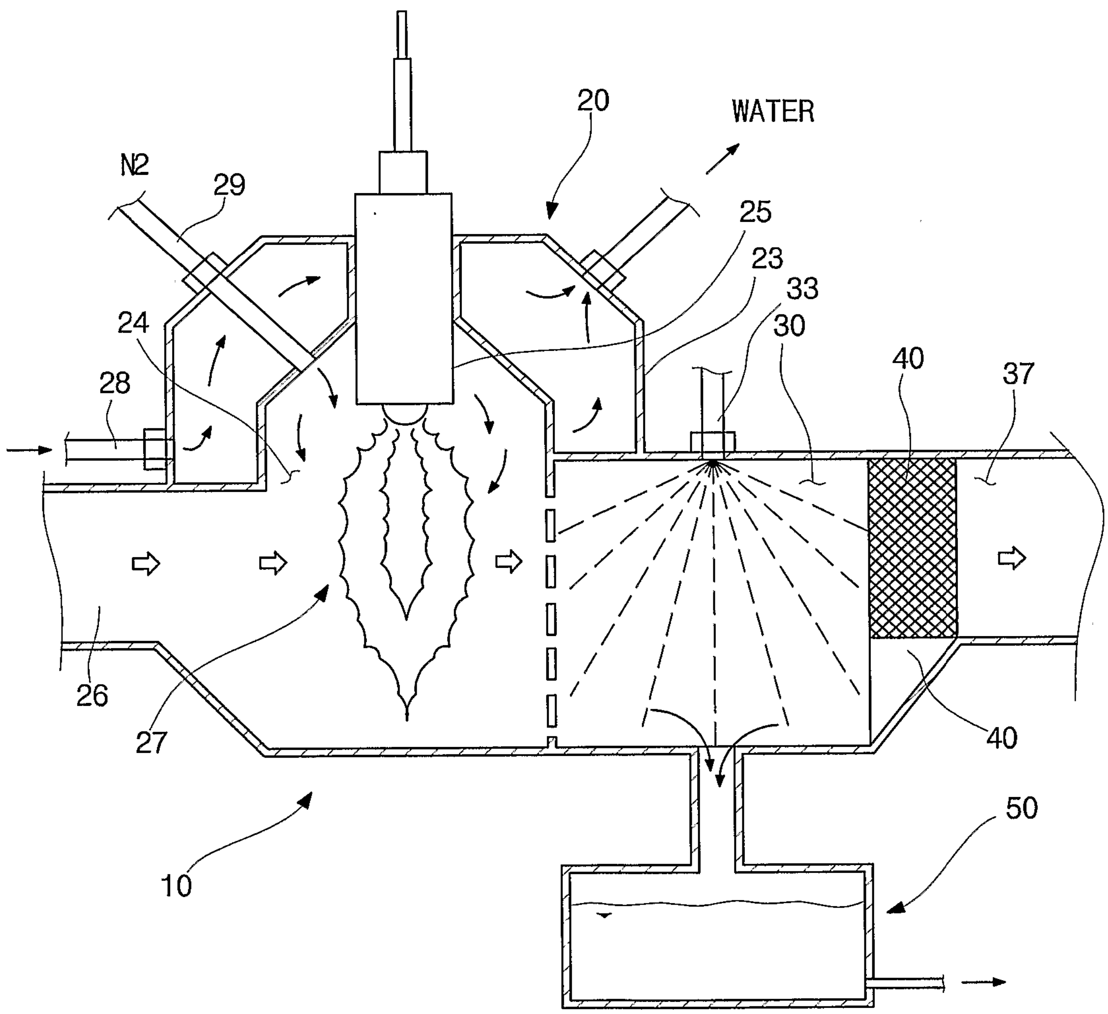


Fig. 5

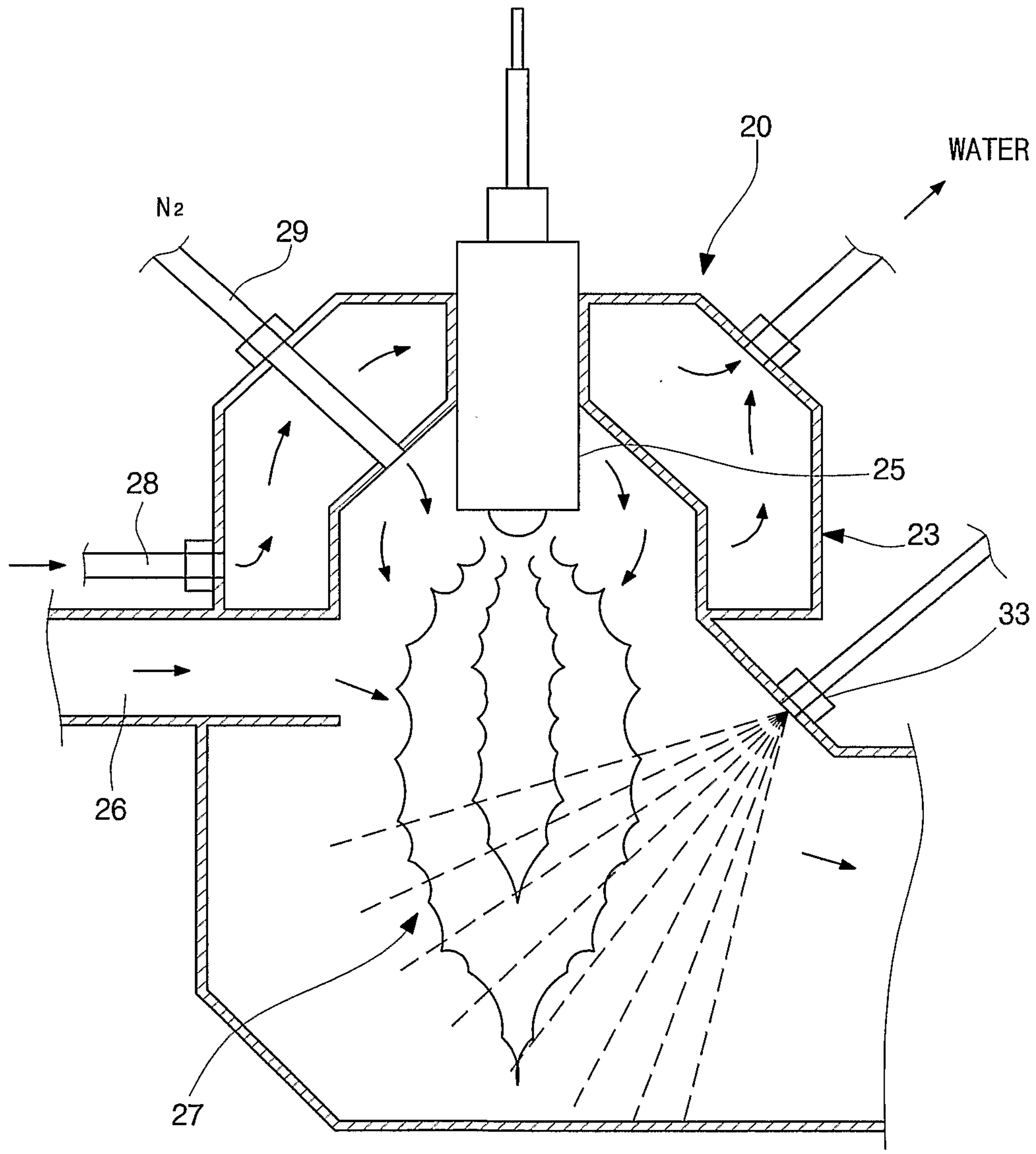


Fig. 6

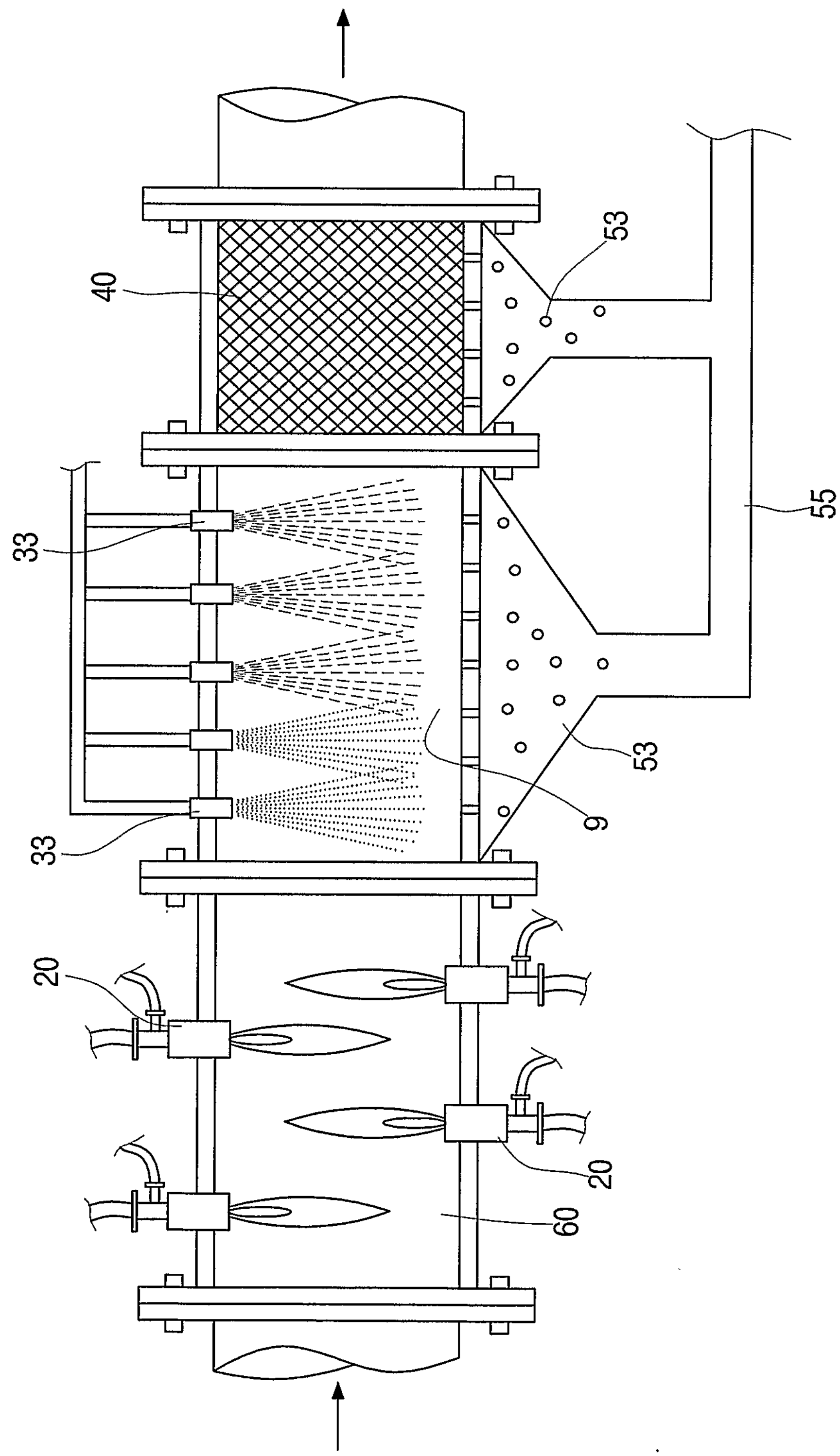
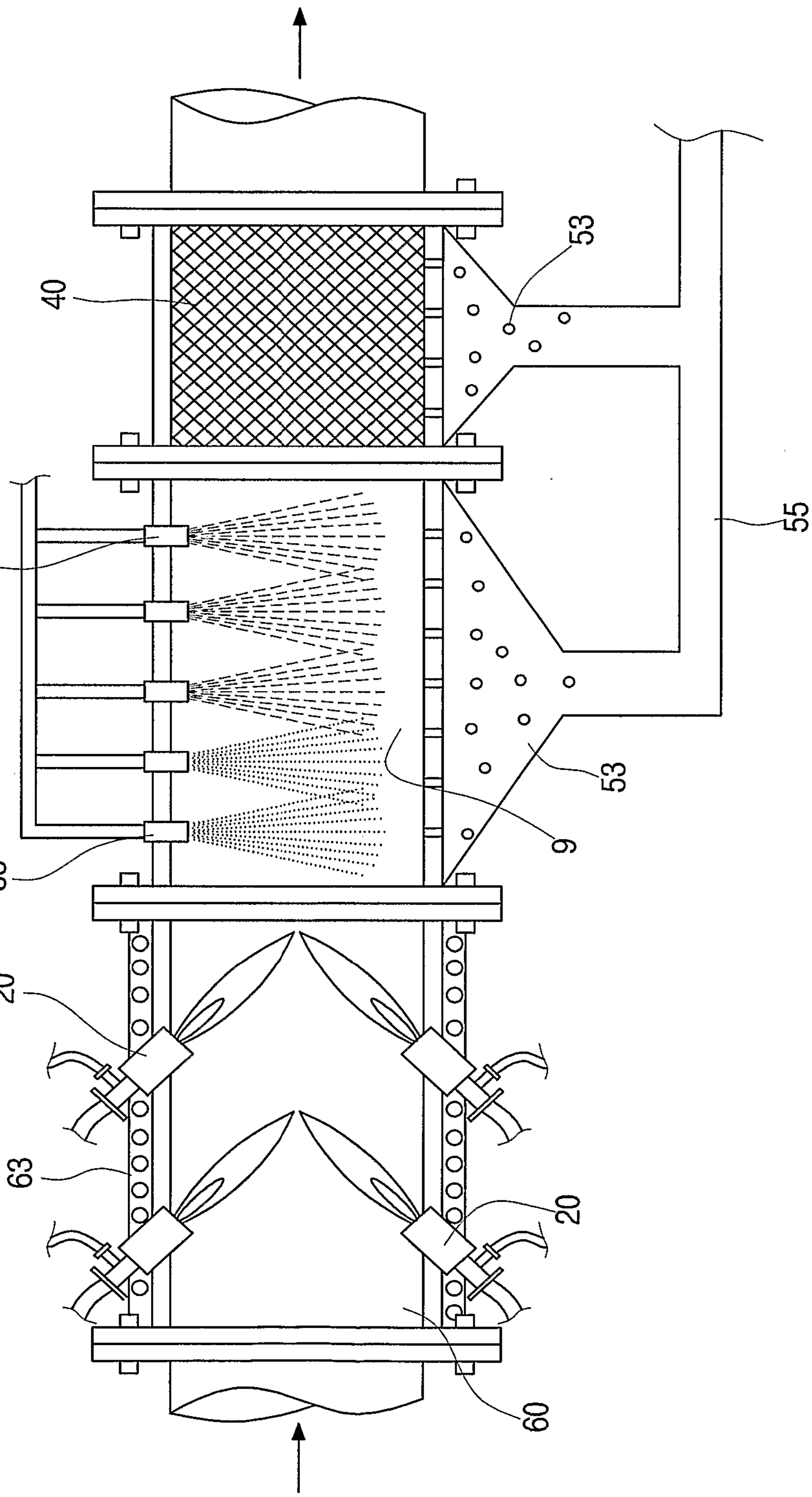


Fig. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR02/00923

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 B01D 53/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and Applications for Inventions since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
NPS, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 09-299762 A (TOSHIBA CORP) 25 November 1997 see the whole document	1-11
Y	JP 08-318129 A (NIPPON STEEL CORP CLEAN JAPAN CENTER) 03 December 1996 see the whole document	1-11
Y	JP 08-323133 A (NIPPON STEEL CORP CLEAN JAPAN CENTER) 10 December 1996 see the whole document	1-11
A	JP 10-249151 A (KOREA HEAVY IND AND AMP) 22 September 1998 see the whole document	1-11
A	JP 08-150315 A (YOSHINAKA SATORU) 11 June 1996 see the whole document	1-11
A	US 5505909 A (GRIMMA MASCH ANLAGEN GMBH) 09 April 1996 see the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevence
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 NOVEMBER 2002 (28.11.2002)	29 NOVEMBER 2002 (29.11.2002)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR02/00923

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 09-299762	25-11-97	NONE	
JP 08-318129	03-12-96	NONE	
JP 08-323133	10-12-96	NONE	
JP 10-249151	22-09-98	KR 213812 B1 CN 1203829 A	02-08-99 06-01-99
JP 08-150315	11-06-96	NONE	
US 5505909	09-04-96	NONE	